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State of Utah
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DIVISION OF WATER QUALITY

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June 15, 1992

Certified Mail
(return receipt requested)

Mr. Glen Eurick
Environmental Affairs Coordinator
Barrick Mercur Gold Mine
P.O. Box 838
Tooele, Utah 84074

RE: Dump Leach No. 3 Ground Water Monitoring Well Network - *Final Determination and Request for Additional Monitoring Well*, Notice of Expiration of Authorization to Operate, Ground Water Quality Discharge Permit No. UGW450001

Dear Mr. Eurick:

This letter is to convey our determinations regarding several reports required by our December 18, 1990 Conditional Approval, and to request the installation of one additional ground water monitoring well at Dump Leach No. 3.

Three reports submitted in your behalf by Dames & Moore have been reviewed, including: 1) February, 1991 Results of Joint and Fracture Characterization Study and Barrick response of June 5, 1991, 2) August 30, 1991 2-D Modeling Results Dump Leach Area No. 3, and 3) May 4, 1992 Evaluation of Leak Detection System, Dump Leach Area #3. We have also reviewed a Barrick report of February 19, 1991, Water Balance Monitoring and Head Control Plans, and a May 1, 1991 response to a previous Notice of Noncompliance.

In addition, we acknowledge an April 6, 1992 meeting between our staff, yourself, and J.B. Brown and Lori Robison of Dames and Moore, wherein discussions were held regarding our review of the first two above mentioned reports.

Executive Secretary Determinations

Based on our review of the above mentioned reports, we have made the following determinations regarding the existing ground water monitoring well network at Dump Leach No. 3:

1. February, 1992 Results of Joint and Fracture Characterization Study and Barrick Response of June 5, 1991

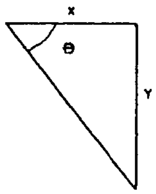
   A. Point Maxima - accepted practice dictates that the point maxima of each joint set represents the preferred joint orientation. The point maxima also represents the preferred orientation for the hydraulic conductivity tensor for the joint set. Averaging the orientations of the individual joints in each set may allow Barrick to suggest an orthogonal relationship exists, however this approach does not represent the preferred joint orientation, nor the hydraulic conductivity tensor. As a result, the simulation of the site with a three dimensional finite difference model, which requires orthogonal tensors, would be difficult.

   B. Effect of Joint Density and Orientation on Contaminant Pathway - we agree with you that the northeast trending joint set D1 may be the predominant conductor of fluids at the Dump No. 3 site due to two factors:

      1) Joint set D1 has about twice the population of joints as the southeast trending joint set D2 (117 joints vs. 61 joints, compare Plates 3 and 4 of the Barrick June 5, 1991 response). Both joint sets appear to have about the same amount of joint aperture width (Plate 11, February, 1991 Report). As a result, because the aperture widths are about the same and because fracture permeability is directly proportional to the density of joints per unit distance across a rock surface, it would appear that the northeast trending joint set D1 would be more permeable than the southeast trending joint set D2.

      2) Joint set D1 consists of joints that are more vertical in that both the point maxima and the average orientation are steeper than joint set D2. The point maxima of set D1 has a dip of 74°, while the point maxima of set D2 has a dip of 65°. For unsaturated flow conditions, where gravity is the major driving force, the joint set with the steepest dip will allow infiltration to travel faster to the water table.

   As fluid follows the joint set on its way to the water table it is shifted or translated horizontally due to the dip of the joints. Based on the point maxima of the predominant northeast striking joint set D1, this horizontal shift is calculated as follows:



$$x = \frac{y}{\tan\theta} = \frac{430 \text{ feet}}{\tan 74°} = 123 \text{ feet to the northwest}$$

where: x = horizontal shift, and
y = vertical distance between bottom of process pool and top of Long Trail Shale.
θ = dip of Long Trail Shale.

If the fluid has to travel any further downward to reach the water table, it will be shifted further northwest. The surface trace of this horizontal shift falls between wells MW-10 and 11 on the north end of Dump Leach No.3.

2. <u>August, 1991 2-D Modeling Results, Dump Leach Area No. 3 Report</u>

A. Streamtube Geometry - Based on the orientation of the flux vectors shown on Plates 8A and 8B, any leachate that may pass out of Dump Leach No. 3 will travel vertically along a streamtube for a distance of about 330 feet, whereupon the streamtube is refracted by and flows parallel to the no-flow boundary imposed by the Long Trail Shale. This causes the streamtube to intersect the water table about 130 feet above and 200 feet east of the well screen of well MW-10. Thanks to this refraction, the stream tubes that directly intersect the MW-10 well screen originate at the ground surface west of Dump No. 3, and not from directly under the facility. If this behavior holds true under actual field conditions, the vertical unsaturated streamtube would be refracted away from the no flow boundary and diverted in the direction of the principal hydraulic conductivity tensor. In other words, the unsaturated flow would be diverted away from the Long Trail Shale and down the strike and dip of the joint set, reinforcing the importance of the orientation of the joint set (point maxima) on the direction of ground water flow. Furthermore, because many stream tubes converge on the area where the water table meets Long Trail Shale, unsaturated flux is concentrated in this area, resulting in several small seepage faces upslope of the intersection of the water table and the shale.

B. Effect of Dispersion - all the sensitivity cases presented illustrate a significant amount of transverse dispersion of the contaminant during travel in the unsaturated zone. If the ground water flow system behaves as a porous media or Darcy continuum, as the model assumes, this lateral dispersion would suggest that even though well MW-10 is not located directly in the same streamtube that exits from below the dump leach (direct contaminant pathway), the contaminants may spread enough laterally during travel to the water table such that MW-10 may be effective in monitoring the site.

C. Most Sensitive Input Parameter: Leakage Rate - we agree with your conclusion that of all the input parameters to the model, the most sensitive appears to be leakage rate from the dump leach. An increase from 0.001 to 0.3 feet/day (300-fold) caused a dramatic change in both the width of the plume and the hydraulic gradient; the 1/2 plume width greatly exceeded 1200 feet and caused the water table to rise over 600 feet. No other parameter caused such a response, not even a 1000-fold increase in vertical hydraulic conductivity (compare Cases 4 and 6). This reinforces the need to conduct head control and water balance monitoring at the facility.

D. Argument Against a Darcy Continuum - evidence collected by Barrick thus far does not suggest that the aquifer beneath Dump Leach No. 3 behaves as a continuous porous medium or Darcy continuum. This conclusion is based on the following facts:

1) Long Term Ground Water Pump Test - as you recollect the pump test conducted in January, 1991 between wells MW-10, 11, and 13 was unsuccessful in demonstrating interconnection between all three wells. However, there was a slight water level response in well MW-13 which may have represented some degree of interconnection between it and the pumping well, MW-10.

2) Inorganic Ground Water Geochemistry - we have reviewed 109 ground water quality samples collected by Barrick during the last two years from wells MW-10, 11, and 13, and plotted the major ion concentrations on a Piper diagram, see attachment. The results of these analyses are consistent with the earlier data which suggested that the ground water in each well has its own distinct and separate geochemical signature. Though all three wells consist of a mixture of the three major anions, well MW-11 is more bicarbonate dominant (about 60%), well MW-10 contains more sulfate (about 35%), and well MW-13 contains a significant amount of chloride (about 50%). If the aquifer was a Darcy continuum, one that has existed for millions of years having cycled its water content many times, one with relatively young ground water (less than 40 years) in it today as evidenced by tritium analysis; one would not expect such a wide variation in geochemistry over such a small horizontal distance as 1,500 feet.

3) Well Hydrographs - we have evaluated 100 water level measurements made by Barrick during the period of April, 1990 to April, 1992 in wells MW-10, 11, and 13. These measurements were plotted on well hydrograph charts with the total monthly precipitation for analysis, see attachment. As can be seen on the chart, wells MW-10 and 11 have

essentially the same water level response during the period. However, well MW-13 does not show the same trend or magnitude of response. This hydrograph suggests that wells MW-10 and 11 may be interconnected or at the least their aquifers have been subjected to the same recharge trend. This is contrary to the long term pump test which indicated that no interconnection existed between these two wells, but suggested it may exist between wells MW-10 and 13. The water level response in both MW-10 and 11 also suggest about a three month lag time between a pulse in local precipitation and a peak in their water levels.

4) Isotopic Ground Water Chemistry - the higher chloride content in well MW-13, which is an anion that is easily flushed from ground water flow systems, and a dampened hydrograph trend in the well, would suggest that MW-13 is completed in a portion of the aquifer where horizontal ground water velocity is extremely low. However, the tritium analysis conducted on ground water from all three wells shows that well MW-13 had the highest tritium content, 17.4 +/- 2.6 TU (MW-10 = 6.5 +/- 2.6 TU and MW-11 = 12.7 +/-2.6 TU, see February 28, 1991 Dames & Moore report). This would suggest that MW-13 has the received the greatest amount of recharge from the ground surface, perhaps due to higher vertical permeability. The opposite is apparent with well MW-10, where the short lag time in the hydrograph suggests relatively good interconnection with the ground surface, yet it contained ground water with the lowest tritium content.

3. <u>February 19, 1991 Water Balance Monitoring and Head Control Plans and May 1, 1991 Barrick Response</u>

We reviewed your May 1, 1991 response and have determined that water balance monitoring of inflows and outflows at Dump Leach No. 3, under the best of circumstances, may detect the catastrophic leak rate of 0.3 ft/day used in the 2-D modeling report. As a result, this monitoring will need to be used in conjunction with other environmental monitoring for the facility. The lack of detection sensitivity is due to several factors, including high rates of flows in and out of Dump No.3, limits of sensitivity of the various flow measurement equipment, and the inability to independently measure unsaturated storage changes (δN).

Inability to measure δN, should not deter the utility of water balance monitoring, however. Barrick has estimated that the unsaturated ore in the dump has a moisture content of about 7 to 11% during leaching conditions (Barrick May 1, 1991 letter, p. 2). Since the total porosity of run-of-mine materials is about 23.7%, this represents an unsaturated storage volume of about one-third to one-half of the possible saturated storage.

The average daily change in saturated storage reported by Barrick shows that this variable contains 5 significant figures. As a result, the average unsaturated storage change would represent one-third to one-half of this value, a term of 4 significant figures. The average daily values for barren flow and pregnant liquor represent terms of 7 significant figures. Consequently, a difference of 3 significant figures exists between the daily average barren and pregnant flows and any change in daily average unsaturated storage. Therefore, the unsaturated storage term can be ignored in the water balance equation if the Inflow/Outflow (I/O) Ratio is held to only three decimals.

As a result, the permit will soon be modified to require I/O Ratio monitoring which ignores δN, with an upper limit of three decimals. This monitoring will be used as a method to evaluate the performance of the facility and liner technology. Although this monitoring is not as sensitive as once hoped, it may provide an early warning of a potential catastrophic release from the dump leach; hopefully much sooner than can be expected from ground water monitoring wells.

4. May 4, 1992 Evaluation of Leak Detection System, Dump Leach Area #3

A. Lower Burrito Leak Detection Effectiveness - no supporting information and description was provided to justify the 1.15×10^{-8} cm/sec permeability reported for raked run-of-mine (ROM) material. In addition, it is apparent that the 12 inch deep trench cut into the raked ROM material may have cut thru the raked layer, since said layer is reported to have been only 4 to 12 inches thick. As a result, the subbase to the Lower Burrito may consist of coarser material which may have a much higher permeability, perhaps as high as 2.2×10^{-3} cm/sec. This is the permeability used for ROM by Barrick's consultants in evaluation of the stability of the upstream buttress construction at the Tailings Pond ("Supplemental Analysis Upstream Construction Option" November 12, 1990 by Physical Resource Engineering, Inc., p.8 and Table 3-1, Zone VI). Such a high permeability combined with the limited area of leak detection reported, 2 to 10 lateral feet from the burrito, leads us to agree with you that the Lower Burrito is inadequate as a leak detection system or a compliance monitoring point for purposes of the Ground Water Discharge Permit. Despite the lack of sensitivity this system may have, conditions will be placed in the revised permit to define that the occurrence of leakage in the lower burrito be interpreted as a violation of the permit.

B. Upper Burrito - no leak collection efficiency information was provided for the upper burrito. Though we agree in concept that the upper burrito should be more sensitive and efficient in collecting leakage due to its underlying clay and FML; it is limited in its ability to detect leakage from an extended distance or report it rapidly. Contrary to the statement on page 6 of your May 4, 1992 report, Barrick has no evidence that the drainage pipe retains a minimum diameter of one inch in its upper reaches, since the 1.425 inch probe could not be inserted beyond the 630 feet from the downstream end of the pipe. This means that approximately 300 feet of the upper portion of the pipe may be crushed or sheared. In addition, samples collected by Barrick indicate fluids in the pipe contain free cyanide in excess of 0.2 mg/l; total cyanide concentrations would be even greater. Consequently, after all these considerations we have determined that the upper burrito is of value but limited in its reliability. Therefore, any flow or water quality monitoring therefrom will be used only in conjunction with ground water quality and water balance monitoring.

5. <u>Final Conclusions</u>

The ground water hydrology of the Dump Leach No. 3 site is extremely complex. It is a flow system controlled by local geologic structure, primarily by a system of fractures in the Upper Member of the Great Blue Limestone and by a basal no-flow boundary consisting of the Long Trail Shale. Local geologic conditions, including general structure, strike and dip of beds, joint orientation and density are known with some degree of confidence. The same cannot be said for the ground water hydrologic conditions. Many lines of evidence gathered thus far, thru extensive efforts by Barrick, do not converge or conclusively demonstrate that the local aquifer behaves as a porous medium or a Darcy continuum. The possibility that the aquifer system could consist of a group of fracture conduits, each with its own set of hydraulic properties and acting independent of each other, cannot be ruled out at this time based on the available information.

Until these fundamental issues can be resolved it is extremely difficult to determine with any confidence that our conceptual model of the local ground water flow system is adequate or representative. This obstacle makes any additional two-dimensional flow or contaminant transport modeling of the site unwarranted, and any three-dimensional modeling extremely unwarranted.

Despite initial optimism that the collection of additional ground water quality and head data and the 2-D modeling could resolve all the issues that were before us a year ago, the results thus far have prevented the achievement of this goal. However, it also appears that the level of effort to collect the needed hydrogeologic information to resolve these issues may be very extensive or even impossible.

Other monitoring mechanisms at the facility are limited in their sensitivity or reliability to detect leakage from the operation. This includes the leak detection by means of the upper burrito and the use of water balance monitoring. Consequently, neither of these two means can supplant or supercede ground water quality monitoring, but must be used in conjunction therewith.

As a result of all these considerations and in order to establish a reliable foundation for ground water monitoring, we believe the local geologic conditions should form the fundamental basis for the design of the ground water monitoring well system. Such an approach is justified due to our greater understanding of the local geology at the site and the complexity and uncertainty of the hydrologic evidence. This means that the orientation and relative permeability of the local joint sets should form a major role in the design of the ground water monitoring well system. Review of the available data suggests that an additional well is needed to monitor any leachate that may travel along the point maxima of the most permeable joint set, set D1.

Formal Executive Secretary Request for Additional Monitoring Well

Pursuant to Condition No. 6 of our December 18, 1990 Conditional Approval, we believe it necessary to install one additional ground water monitoring well at Dump Leach No. 3 in order to complete an adequate monitoring well network. This well must be located on the north side of Dump Leach No. 3 between the leach plant and the retention basin in Dead Horse Canyon at the following approximate local coordinates: North 28,800 feet and East 21,200 feet. This location is approximately 400 feet east of well MW-11 and 750 feet north of well MW-10. Said well shall be completed in and across the local water table and constructed in compliance with Part I.H.4 of the permit.

Pursuant to Part I.E.3 of your Ground Water Discharge Permit, we request that you submit a comprehensive plan and compliance schedule for the installation of this new monitoring well within 30 days of receipt of this letter. Said plan must include the proposed location, projected depth, and monitoring well design. Said compliance schedule must include:

A. Installation of the additional well on or before September 1, 1992, and

B. Submittal of an "As-Built" Report on or before October 1, 1992, pursuant to Part I.H.4(b) of the permit, and

C. Completion of a year of accelerated background sampling in compliance with Part I.H.5 of the permit, and submittal of an Accelerated Background Report on or before October 1, 1993.

Upon satisfactory completion of this request and subsequent modification of the existing permit to address all the compliance issues raised above, Barrick shall have satisfied all the outstanding conditions of the December 18, 1990 Conditional Approval. Such resolution of these issues will allow Barrick to operate Dump Leach No. 3 in an unconditional status, under the authority of the modified ground water discharge permit.

Please be advised that your January 27, 1992 authorization to operate Dump Leach No. 3 has expired. It is therefore imperative that you fully and adequately respond to this request as soon as possible, so that we may consider an appropriate extension.

If you have any questions or comments, please call Loren Morton at 538-6146. We appreciate your continued cooperation.

Sincerely,

Utah Water Quality Board

Don A. Ostler

Don A. Ostler, P.E.
Executive Secretary

Enclosure

DAO:lbm:lm

cc: Geoff Freethey, USGS, WRD-SLC
Lori Robison, Dames & Moore
J. B. Brown, Dames & Moore
Wayne Hedberg, DOGM
Myron Bateman, Tooele Co. Health Dept.

O:BMD3GWMW.NOD
FILE:GW-BARRICK DUMP 3

109 samples

MW-10: 4/11/90 - 4/7/92

MW-11: 4/18/90 - 4/8/92

MW-13: 11/16/90 - 4/1/92

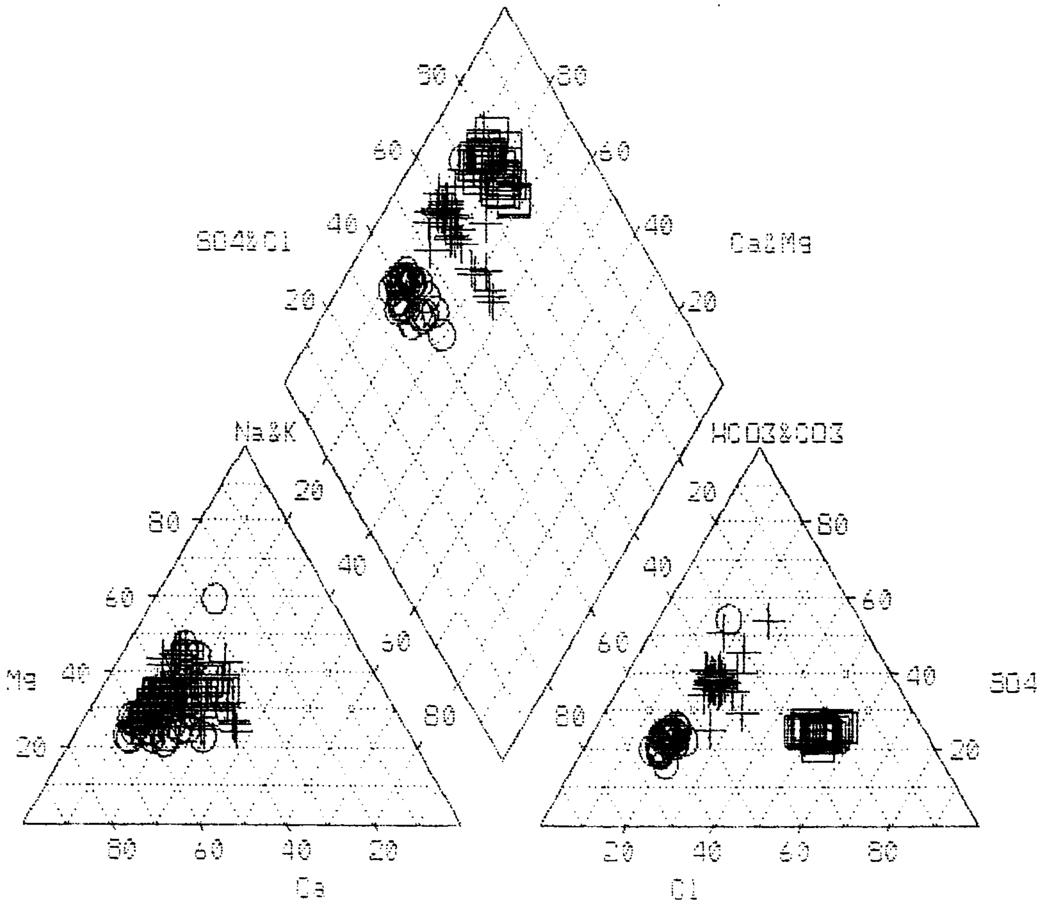
HC-GRAM

HydroChemical Graphic Representation Analysis Methods

Version: HC-GRAM 1.42

27-May-1992 13:44:42.76

Project: Barrick Dump 3: MW-10 = +, MW-11 = o, MW-13 = ¤



Barrick Mercur Dump 3 Wells Hydrograph